1. Observatory Operations Division

1.1. Mauna Loa Observatory

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1.1.1. Operations

MLO is undergoing an evolution in data gathering and data transmission brought on by the availability of inexpensive and reliable PCs and the Internet. In 1993 MLO continued the process of expanding the number of measurements accessible in essentially real time via Internet and/or telephone modems. With the planned connection of the carbon cycle measurements to Internet in late 1994 and the halocarbons in 1995, the process will be near completion. Thus, by the end of 1995 all the continuous, automatic MLO measurements will be monitored (and in some cases, instruments adjusted) by PIs from their office computers wherever in the world they may be. Because of this movement to PC-based data monitoring systems at MLO, the venerable CAMS units are being replaced. With the upgrading of the carbon cycle CO_2 systems, the CAMS era at MLO will come to an end.

Early in the year, the MLO outdoor electrical upgrade was completed and accepted coincident with a major upgrade of Hawaiian Electric's Hawaii Island generating capacity. Together, these new facilities reduced the number of power interruptions at MLO from 25 in January to 2 in February. Power problems were thought to be bad memories until July 24 when a lightning strike traveled backward through the now well-grounded MLO system and burned out about a dozen instruments. On a positive note, the breakers on the hot side worked in this lightning strike. The situation is now being monitored and isolating some sections of the grounding network should lightning damage occur again may be considered.

A major staff change occurred in June when the electronic engineer, who ran the MLO lidar program for 13 years, moved to a management position with the NOAA Space Environment Laboratory in Boulder. He was replaced in July by a physical scientist from the University of Michigan, Ann Arbor, in a smooth transition.

The JPL ozone lidar measurement system (part of the NDSC program) arrived on site in July in two 13-m (40 ft) trailers that were installed on a cement pad immediately east of the AEC building. The lidar is operated by one of a rotating crew of three from JPL, Pasadena, California, who spend 3-4 weeks per shift in Hawaii. The JPL lidar group works closely with the NOAA lidar group in conducting coincident aerosol and temperature profiles. The JPL ozone profiles are compared with the weekly MLO ozonesonde profiles with generally excellent agreement.

Electrical power with 14 separate circuits (including 2 RV and 2 at 220 V) has been installed at the base of the Cape Kumukahi lighthouse tower, and four air lines run to the top of the 18-m (60-ft) tower. Air Cadet pumps (one of which is pumping continuously) are mounted under a movable metal cover at the tower base and are used for the URI and SIO oxygen flask sampling programs. A 15 m × 15 m fenced enclosure is planned for construction just south of the tower to protect trailers and containers brought to Cape Kumukahi for future marine boundary layer measurement programs.

Through an arrangement with Western Pacific Communications, Hilo, a radio telephone transceiver station was installed at MLO. This provides MLO, JPL, and HAO vehicles with uninterrupted telephone communications on the Saddle and Observatory Roads, including the portion of the Saddle Road down to the Kona Coast. This communication link will be a valuable safety asset during the NDSC building construction phase.

The transfer of the NDSC land from the state of Hawaii to NOAA was approved by the Department of Land and Natural Resources. Complete and clear title to the 4-acre parcel should occur in 1994 or early 1995.

In September, commercial bike tours began operating on the Observatory Road. The tours consist of a van depositing mountain bikes and riders at MLO from where they coast approximately 51 km down to Kona. MLO is working with these companies (now numbering two) to make their riders visible to Observatory Road vehicle traffic. Early groups were riding black bikes, wore black T-shirts and helmets, and coasted head-down in the center of the road. Now at least they wear orange vests, white helmets, and are told to be aware of vehicle traffic.

MLO was host to 399 signed-in visitors in 1993. Countries represented were Canada, Japan, China, Germany, Burkina-Faso, Switzerland, France, Togo, Australia, Brazil, Russia, Iran, England, Denmark, American Samoa, Mexico, Singapore, Italy, Holland, New Zealand, Norway, and Sweden. This was in addition to visitors from 26 states. Most of the visiting scientists were given a tour and reprints of the most up-to-date CMDL data plots MLO had available. MLO keeps a store of color plots on hand for such occasions.

1.1.2. Programs

Table 1.1 summarizes the programs in operation at MLO during 1993. Relevant details of note on the respective programs are as follows:

Carbon Dioxide

The CMDL Siemens Ultramat-3 IR CO_2 analyzer and the SIO Applied Physics IR CO_2 analyzer were operated in parallel without major problems throughout the year.

TABLE 1.1. Summary of Measurement Programs at MLO in 1993

Program	Instrument	Sampling Frequency
Gases		
CO_2	Siemens Ultramat-3 IR analyzer	Continuous
	0.5-L glass flasks, through analyzer	1 pair wk^{-1}
CO	Trace Analytical RGA3 reduction gas analyzer no. R5	Continuous (5/92)
CO_2, CH_4, CO, ^{13}C, ^{18}O of CO_2	2.5-L glass flasks, MAKS pump unit*	1 pair wk^{-1}
	3-L evacuated (KUM)	1 pair wk^{-1}
CH_4	Carle automated GC no. 6	1 sample (24 min)$^{-1}$
Surface O_3	Dasibi ozone meter	Continuous
Total O_3	Dobson spectrophotometer no. 76	3 day^{-1}, weekdays
O_3 profiles	Dobson spectrophotometer no. 76 (automated Umkehr method)	2 day^{-1}
	Balloonborne ECC sonde	1 wk^{-1}
N_2O, CFC-11, CFC-12, CFC-113, CH_3CCl_3, CCl_4	300-mL stainless steel flasks	1 sample wk^{-1}
N_2O, CFC-11, CFC-12, CFC-113, CH_3CCl_3, CCl_4, HCFC-22, HCFC-141b, HCFC-142b, CH_3Br, CH_3Cl, CH_2Cl_2, $CHCl_3$, C_2HCl_3, C_2Cl_4, H-1301, H-1211	850-mL stainless steel flasks	1 sample mo^{-1}
CFC-11, CFC-12, CFC-113, N_2O, CCl_4, CH_3CCl_3,	HP5890 automated GC	1 sample h^{-1}
N_2O	Shimadzu automated GC	1 sample h^{-1}
Radon	Two-filter system	Continuous integrated 30-min samples
Aerosols		
Condensation nuclei	Pollak CNC	1 day^{-1}
	TSI CNC†	Continuous
Optical properties	Four-wavelength nephelometer†: 450, 550, 700, 850 nm	Continuous
Stratospheric and upper tropospheric aerosols	Lidar, 694.3 nm	1 profile wk^{-1}
Black carbon	Aethalometer	Continuous
Solar Radiation		
Global irradiance	Eppley pyranometers with Q, OG1, and RG8 filters	Continuous
Direct irradiance	Eppley pyrheliometer (2) with Q filter	Continuous
	Eppley pyrheliometer with Q, OG1, RG2, and RG8 filters	3 day^{-1}
	Eppley/Kendall active cavity radiometer	1 mo^{-1}
Diffuse irradiance	Eppley pyrgeometer with shading disk and Q filter†	Continuous
Terrestrial (IR) radiation	Global downwelling IR pyrgeometer	Continuous (11/93)
Turbidity	J-202 and J-314 sunphotometers with 380-, 500-, 778-, 862-nm narrowband filters	3 day^{-1}, weekdays
	PMOD three-wavelength sunphotometer†: 380, 500, 778 nm; narrowband	Continuous
Column water vapor	Two wavelength tracking sunphotometer: 860-, 940-nm	Continuous (4/92)
Meteorology		
Air temperature	Aspirated thermistor†, 2- and 40-m heights (removed October 1993)	Continuous
	Aspirated thermistor†, 2-, 9-, 37-m heights (added October 1993)	Continuous
	Max.-min. thermometers, 2-m height	1 day^{-1}

TABLE 1.1. Summary of Measurement Programs at MLO in 1993—Continued

Program	Instrument	Sampling Frequency
Meteorology - Continued		
Temperature gradient	Aspirated thermistors†, 2- and 40-m heights (removed October 1993)	Continuous
	Aspirated thermistors†, 2-, 9-, 37-m heights (added October 1993)	Continuous
Dewpoint temperature	Dewpoint hygrometer†, 2-m height	Continuous
Relative humidity	TSL 2-m height	Continuous
Pressure	Capacitance transducer†	Continuous
	Mercurial barometer	5 wk^{-1}
Wind (speed and direction)	Bendix Aerovane†, 8.5- and 40-m heights (40-m Aerovane removed October 1993)	Continuous
Wind (speed and direction)	8.5-, 10-, and 38-m heights (added October 1993)	Continuous
Planetary boundary layer meteorology (PBL MET)	Wind vane, cup anemometer, and aspirated RTD thermometer (direction, speed, temperature at 3-, 5-, 10-, 20-, 30-, and 40-m levels) (removed October 1993)	Continuous
Precipitation	Rain gauge, 20-cm	5 wk^{-1}
	Rain gauge, 20-cm‡	1 wk^{-1}
	Rain gauge, tipping bucket†	Continuous
Total precipitable water	Foskett IR hygrometer†	Continuous
Precipitation Chemistry		
pH	pH meter	Daily
Conductivity	Conductivity bridge	Daily
Cooperative Programs		
CO_2 (SIO)	Applied Physics IR analyzer	Continuous
CO_2, ^{13}C, N_2O (SIO)	5-L evacuated glass flasks*	1 pair wk^{-1}
CO_2, CO, CH_4, $^{13}C/^{12}C$ (CSIRO)	Pressurized glass flask sample	1 mo^{-1}
CH_4, CH_3CCl_3, CH_3Cl, F-22, F-12, F-11, F-113 CO, CO_2, N_2O, $CHCl_3$, CCl_4 (OGIST)	Pressurized stainless steel flasks	3 wk^{-1}
O_2 analyses (SIO)	5-L glass flasks through tower line and pump unit* (started June 1993)	3 (2 mo)$^{-1}$
O_2 analyses (URI)	3-L glass flasks through tower line and pump unit (started June 1993 at KUM)	2 (2 mo)$^{-1}$
CH_4 ($^{13}C/^{12}C$) (Univ. of Washington)	35-L evacuated flask	1 mo^{-1}
Total suspended particles (DOE)	High-volume sampler (1 filter wk^{-1})	Continuous
Ultraviolet radiation (Smithsonian)	Eight-wavelength UV radiometer: 290-325 nm; narrowband	Continuous
Ultraviolet radiation (ARL)	Robertson-Berger UV radiometer (erythema)	Continuous
UV solar radiation (ARL)	Yankee Environmental UVB pyranometer (280-320 nm)	Continuous (10/92)
Ultraviolet radiation (Univ. of Hawaii)	Robertson-Berger UV radiometer (erythema) (started June 1993)	Continuous
Solar aureole intensity (CSU)	Multi-aperture tracking photometer: 2, 5, 10, 20, 30° fields of view	Continuous
Precipitation collection (DOE)	Exposed collection pails	Integrated monthly sample
Precipitation collection for organic acid analysis (Univ. of Virginia)	Aerochemetric automatic collector (terminated August 1993)	Collection after each rain event
Wet-dry deposition (ISWS, NADP)	Aerochemetric automatic collector and weighing-bucket rain gauge	Integrated 7-day sample
Aerosol chemistry (Univ. of Calif.-Davis)	Programmed filter sampler	Integrated 3-day sample 1 continuous and 1 down-slope sample (3 days)$^{-1}$
Various trace gases (OGIST)	Stainless steel flasks*	1 set wk^{-1} (3 flasks)
Sulfate, nitrate, aerosols (URI)	Filter system	Daily, 2000-0600 LST

TABLE 1.1. Summary of Measurement Programs at MLO in 1993—Continued

Program	Instrument	Sampling Frequency
Cooperative Programs - Continued		
Radon (ANSTO)	Aerosol scavenging of Rn daughters	Continuous; integrated 30-min samples
Solar spectra (Univ. of Denver)	FTIR spectrometer	1 wk^{-1}

All instruments are at MLO unless indicated.
*MLO and Kumukahi
†Data from this instrument recorded and processed by microcomputers.
‡Kulani Mauka

Routine maintenance and calibrations were undertaken on both instruments as scheduled. An SIO electronic engineer upgraded the SIO CO_2 data acquisition system on March 24-26. Data are now recorded on a Brown strip chart recorder and stored on a PC hard disk. Hourly average CO_2 values are printed out at MLO.

The preliminary average MLO CO_2 concentration for 1993 was 356.8 ppm. The CO_2 annual growth rate between 1992 and 1993 was approximately 0.6 ppm. Compared with the 1990-1991 growth rate of 1.3 ppm per year, and the 1991-1992 growth rate of 0.8 ppm per year, this indicates a continued slowdown in the CO_2 growth rate measured at MLO.

Outgassing from the volcanic vents at the Mauna Loa caldera and along the northeast rift zone at Mauna Loa continued to cause periodic observable disturbances in some of the CO_2 data record. As in prior years, these venting events occurred mostly between midnight and 0800 LST of the following day, during the downslope wind regime. The erratic CO_2 concentration data resulting from these venting events were easily identified by visually scanning chart records or by utilizing a computerized data-screening procedure, and thus they have been separated from the clean-air record without difficulty. Such venting episodes were detected mainly on the basis of criteria for CO_2 concentration, CO_2 variability, and wind sector. The criterion for the CO_2 standard deviation screening was 1.0 ppm, which is the value suggested by *Thoning et al.* [1989].

The frequency of monthly occurrences of observable outgassing from volcanic vents on Mauna Loa for 1993 are listed in Table 1.2, and the annual number of events for the past 6 years are listed in Table 1.3.

The weekly CO_2, CH_4, and other gas sampling programs, using flasks at MLO and at Cape Kumukahi, were carried out according to schedule throughout the year, without major problems.

The flask sampling procedure at MLO was changed as of November 19, 1993:

- For the through analyzer sampling, the 0.5-L greased-type flasks were replaced with 0.5 L Teflon O-ring-type flasks.
- For the MAKS sampling, the 0.5-L Teflon O-ring flasks were replaced with 2.5-L Teflon O-ring flasks.

Carbon Monoxide

A Trace Analytical RGA3 Reduction Gas Analyzer for the continuous measurement of CO mixing ratios was installed in May 1992 and continues to work well. System operations and chromatographic data logging are handled by an HP3396A integrator.

Methane

The Carle automated GC system, Carle 6, was in continuous operation throughout the year providing CH_4 data on the basis of a grab air sample being taken every 24 minutes. The instrument functioned well during the year.

The CH_4 data continued to show clearly defined cycles of varying frequencies. The typical diurnal cycle was well correlated with upslope and downslope winds, with the marine boundary layer air having the higher CH_4 concentrations. There were also multiday or synoptic-scale CH_4 cycles observed that apparently

TABLE 1.2. Estimated Mauna Loa Venting Episodes (Total Time in Hours) at MLO in 1993*

Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Year
1	0	4	1	0	1	1	4	4	2	0	10	28

*Criteria: CO_2 SD ≥1.0 ppm; wind direction sector 135°-225°; wind speed ≥1.35 m s^{-1}.

TABLE 1.3. CO_2 Venting Events From 1988 Through 1993

Year	Total Time (Hours)
1988	200
1989	84
1990	48
1991	26
1992	23
1993	28

relate to different air mass source regions. The average MLO CH_4 concentration for 1993 was ~1728 ppb with the maximum occurring in November (~1750 ppb) and minimum in August (~1720 ppb).

Ozone Monitoring

The 1993 MLO ozone monitoring program consisted of three measurement foci: continuous surface ozone monitoring using a Dasibi model 1003-AH UV absorption ozone monitor; total and Umkehr ozone profile measurements using computer-based automated Dobson instrument 76; and ozone profile measurements based on weekly ascents of balloonborne ECC ozonesondes released from the NWS station at the Hilo Airport. In addition to the daily automated Umkehr measurements and 5-day-a-week total ozone measurements, five special early-morning AD-CD direct sun observations were completed in 1993. The Dasibi ozone monitor performed in a fully satisfactory manner and provided a continuous, high-quality record of station-level ozone concentrations for the entire year.

Halocarbons and Nitrous Oxide

The RITS system had its annual major maintenance in September 1993. During this time, shutoff solenoid assemblies and regulator warmers were added to the CAL1 and CAL2 tanks. Persistent leaks necessitated the replacement of various valves in the stream select unit and a brass actuator in the HP-GC. A new air compressor was installed to replace one that burned out because of the leaks.

In general, the RITS computer continued to experience hangups throughout the year. A bad power supply was replaced in May. Program editing to cut down printing and data handling problems have not solved the computer "glitches."

Radon

The CMDL-DOE radon program completed its third year of operation and collected the first full year of improved data since the instrument background was reduced by applying epoxy over welds inside the instrument. The current background is 8 counts per 30 minutes. A re-examination of the 1991-1992 data suggests that the background was 26 counts per 30 minutes over that period. The 1993 data show excellent agreement with the ANSTO radon monitor data.

Radon concentrations on January 6 reached their highest levels in the 3 years of radon monitoring at MLO, with half-hour averages greater than 2800 mBq m^{-3}. This coincided with the high post-frontal wind flows from a storm on January 4-6.

Aerosol Monitoring

The TSI unit is a continuous expansion CNC in which condensation occurs in butyl alcohol vapor in a chamber and single particle counting statistics are used as a basis for the CN concentration calculations. The instrument has continued to display higher counts than the Pollak counter since its return from the manufacturer in 1991.

The aethalometer performed satisfactorily collecting black carbon data. There was some local contamination of the data during the early part of the year when the observatory electrical upgrade contractor was using diesel equipment on site.

The four-wavelength nephelometer went down on January 17 because of a faulty automatic air/filter valve. While awaiting arrival of a replacement valve from Boulder, maintenance was performed on the circuitry. The system was brought back into service on February 26. The system performed without any problems the remainder of the year.

Solar Radiation

With the inclusion of the EKO sunphotometer on the spar in March, MLO is now measuring turbidity in more channels than ever before. The EKO is at MLO on a test basis and will be removed in 1994. Using two handheld sunphotometers, the PMOD sunphotometer, two water vapor meters with two channels each, and the EKO sunphotometer, MLO monitors in three channels at 380 nm, three channels at 500 nm, one channel at 675 nm, two channels at 778 nm, one channel at 862 nm, two channels at 870 nm, and two channels at 940 nm. This is a total of 14 channels at 7 separate wavelengths.

Diffuse pyranometer no. 12562, which had developed a negative offset, was replaced with no. 8031 on January 26. A pyrgeometer (global downwelling IR) began operation for the first time at MLO on November 1. Thirty-five handheld sunphotometer instrument calibrations were performed during the year.

A new data acquisition system was installed on October 12 based on Campbell Scientific modules that allow for direct access via a phone modem or RS232 port. All the solar radiation instruments on the radiation tower, the diffuse pyranometer, the CN counter, and the nephelometer are now being monitored with this system at a 3-min time resolution. When instruments are accessed remotely by phone, data are sent at 3-s intervals and plotted using Campbell Scientific software.

Meteorology

The standard meteorological monitoring equipment was down for a few days after the observatory took a direct lightning hit on July 24. It took about a week for all meteorological systems to become fully restored.

There were no changes in the meteorological program other than the data system changes noted under the Computer/Network heading. The PBL system func-tioned without problems through 1993. The system measures wind speed, wind direction, and temperature at the 3-, 5-, 10-, 20-, 30-, and 40-m levels.

Precipitation Chemistry

The MLO modified program of precipitation chemistry collection and analyses was continued throughout 1993 within the basic MLO operational routine. This program consists of collection of a weekly integrated precipitation sample from the Hilo NWS station and collection of precipitation event samples at MLO. Analyses of these samples are undertaken in the Hilo laboratory for pH and conductivity.

Computers/Network

This is the year that Internet access was established, and it is rapidly transforming MLO operations. There is a direct link from the Hilo office to the University of Hawaii, and then to MLO via microwave. The PBL system was the first instrument to send data to Hilo and Boulder via the Internet. Other projects that followed included sending the JPL and CMDL lidar data through fiber optic links to the main MLO building. Ozonesonde data are also sent over the Internet on a weekly basis. With direct toll-free E-mail access available on Internet, this powerful form of communication is heavily utilized by MLO staff, thus cutting down on long-distance toll charges. MLO does not have access to FTS.

The Hilo office has networked all of its PCs and uses Windows for Workgroups for its main operating system. For connection to the VAX, the PCs also run Decnet (Pathworks) and TCP/IP protocols. The VMS operating system on the VAX was upgraded to version 6.

October was the last month of operation for the MO3 CAMS. It was removed on November 1 and replaced by the new PC-based meteorology data system. October was also the last month in which CAMS recorded solar radiation data; the ASR CAMS was replaced by a Campbell Scientific data system on November 1. The ASR CAMS is still connected to the aerosol instruments as a backup to the CSI system and will operate at least through 1994.

Lidar

Lidar operations continued on a regular weekly basis from February 1, 1993, through the end of the year. During January the repair of the laser power supply was completed. In October and November a new computer system (Gateway 80486 DX, 33 MHz) for controlling the laser and the data acquisition electronics replaced the old computer. The laser power supply was modified to accept a trigger from the new computer. A new digital I/O board provides this trigger and is the interface with the data acquisition electronics. The instrument now runs automatically but still requires the operator to monitor the laser power and adjust it periodically. The raw data are displayed in real time and can be used to adjust the laser. The control and analysis software has been written in Turbo Pascal to run on the new computer.

Observations of the decay of the Mount Pinatubo aerosols continued, allowing comparisons to be made with the El Chichon eruption. In Figure 1.1 the integrated aerosol backscatter is shown for the period from 1980 to present. The complete ruby lidar record at MLO extends back to December 1974. The backscatter is integrated from slightly below the tropopause to well above the stratospheric aerosol layer.

The period from 1989 to 1991 would appear to show measurements of the stratospheric background level. No significant eruptions took place during that time, and the level appears constant. The average integrated aerosol backscatter is 0.69×10^{-4} sr^{-1}. After subtracting this level from the data, decay lifetimes of 7.4 months and 11.5 months were calculated for Pinatubo and El Chichon aerosols, respectively.

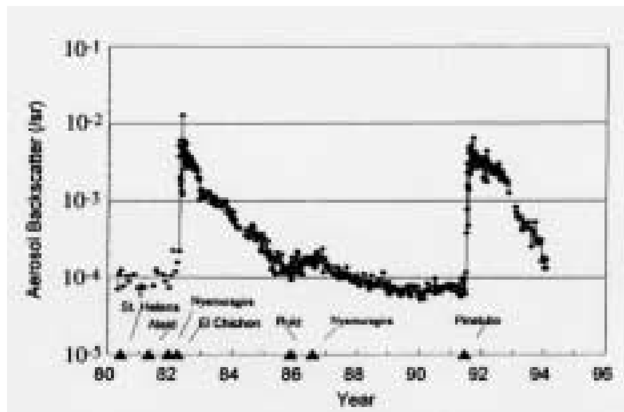

Fig. 1.1. Stratospheric column integrated aerosol backscatter measured with the MLO ruby lidar since 1980. Between 1980 and 1982 the data are monthly averages; after 1982 each observation is shown.

Outgassing of Mauna Loa Volcano

Trace gas and aerosol measurements made at MLO have been analyzed in a special study aimed at characterizing the quiescent volcanic plume coming from the 6-km-distant summit of Mauna Loa volcano. The volcano has long been recognized as a source of CO_2 and aerosols. Previous studies have been concerned with identifying and eliminating this contamination from the climatological baseline record.

In this study, minute-scale variability in the atmospheric CO_2 concentration was used to identify the presence of the volcanic plume at night in the downslope wind.
The excess concentration of gases and aerosols above background levels was calculated for each hour in which the plume was present. The frequency of night-time hours in which the plume was detected varied between 50% and about 5%. In the months after the 1984 eruption, the plume CO_2 occasionally saturated the analyzer output; an extrapolation model suggests that hourly excess CO_2 may have reached levels greater than over 600 ppm above baseline. The excess CO_2 was greatest when winds blew from the direction of the summit (180° to 190°), with a small, sympathetic peak when winds came from east of

130° (Figure 1.2). The plume was frequently trapped beneath the night-time surface temperature inversion and had a scale height of tens of meters. The average strength of the plume at MLO followed the evolution of the temperature inversion, forming after sunset, gradually intensifying, and reaching a stable maximum between 0100 and 0600 LST.

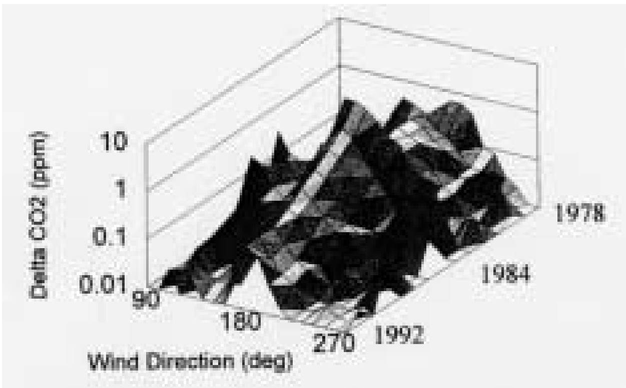

Fig. 1.2. Yearly average excess CO_2 between 2000 and 0759 LST in 10° wind direction bins between 1978 and 1992. Excess CO_2 was normalized to a standard sampling height of 23 m. Winds outside of 10° to 260° blew too infrequently to yield statistically signficant excess CO_2 values.

Excess CO_2 was measured in the plume throughout the 1958-1993 period of record. The amount of CO_2 was greatest shortly after eruptions (1950, 1975, 1984) and decreased exponentially in the following years, as may be observed in Figure 1.3. The rate of decrease following the 1984 eruption was about 6 times greater than that after the 1975 eruption. The post-1958 rate of decrease was similar to that after 1975. The onset of enhanced outgassing was delayed by 65 days following the 1975 eruption and by less than 20 days following the 1984 eruption. Neither eruption was preceded by any outgassing activity that could have been used to predict the eruption.

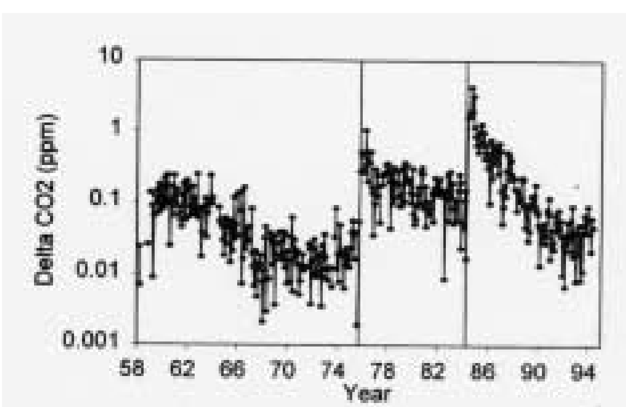

Fig. 1.3. Monthly average excess CO_2 between 2000 and 0759 LST normalized to a standard sampling height of 23 m. The 1975 and 1984 eruptions are denoted by vertical lines. Data prior to 1976 were derived from hand-scaled data obtained by the SIO; the rest were derived from computer-digitized NOAA data.

Excess aerosol particles were present throughout the 1974-1993 period of record as shown in Figure 1.4. In the post-1975 period, high CN levels were present. After the 1984 eruption, CN levels dropped by a factor of 5 and continued to fall through 1993. Two brief dips that occurred in 1986-1987 and 1990-1991 coincided with periods when geodetic observations showed that the gradual inflation of the summit either halted or was temporarily reversed. Light scattering aerosols were detectable only between 1977 and 1980 and to a lesser degree in 1983. The magnitude of large aerosols in the plume was consistent with the visual thickness of the plume at the vent (Figure 1.4).

Seven additional MLO data sets were examined for a volcanic plume component: H_2O (1974-1993), CH_4 (1987-1993), SO_2 (1988-1992), Aerosol black carbon (1990-1993), radon (1991-1993), CO (1992-1993), and H_2 (1992-1993). None of these species were present in the plume down to the detection limits of the analysis technique.

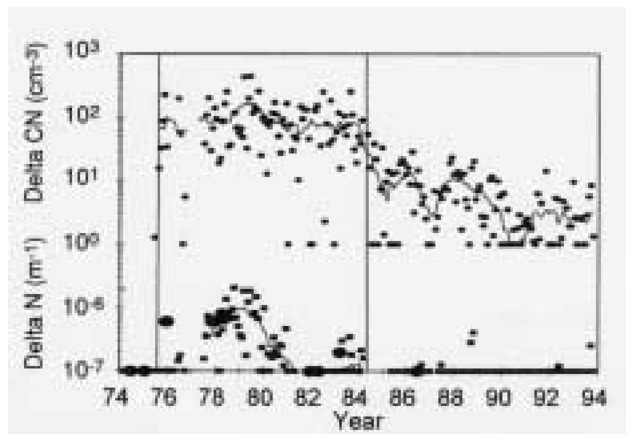

Fig. 1.4. Monthly average excess aerosols between 0000 and 0759 LST measured from a sampling height of 13 m. The fits are 12-mo running means. Excess CN are shown by small ovals with a lower limit of detection of 1 cm^{-3}. Excess 550 nm light scattering (squares) less than 1×10^{-7} m^{-1} is plotted as 1×10^{-7} m^{-1}. The large solid ovals within the light scattering data indicate the visual thickness of the fume at the caldera vent estimated from aerial photographs (on a scale of 0 to 5) and then linearly scaled between 1×10^{-7} and 10^{-6} m^{-1}.

Cooperative Programs

MLO cooperative programs are listed last in Table 1.1; new programs and changes in existing programs are presented below.

The only major new program instituted at the MLO mountain site in 1993 was the University of Hawaii UV radiation measurement (Robertson-Berger meter) installed on June 18, 1993. This instrument has telephone access, and the data are also available on the MLO VAX through Internet.

At the MLO Cape Kumukahi lighthouse tower site, SIO and URI staff installed four Dekobon 6-mm (1/4 in) air sampling lines up to the top of the 18-m tower on June 25-27. Individual Air Cadet pumps are used to draw air through the air intake lines. The sample air will be used for the new SIO and URI oxygen flask sampling programs initiated in June 1993.

SIO upgraded the SIO CO_2 data acquisition system at MLO on March 24-26. The data are now recorded on a Brown stripchart recorder and stored in a PC hard disk. The hourly average CO_2 values are printed out on the PC printer at the observatory.

The formation of ^{3}He (WHOI), O_2/N_2 flask sampling (NCAR), and University of Washington aerosol chemistry programs were discontinued in 1993.